

Crash Injury Data for Automotive Engineers

Lessons from Real Life

Stewart C. Wang MD PhD FACS

University of Michigan Trauma Center

University of Michigan Program for Injury Research and Education

Motor Vehicle Crashes

- 1,000,000 deaths per year worldwide
- No. 2 global health problem by the year 2020 – W.H.O.

Crashes in the USA

40,000 killed

(115/day, 1/13 minutes)

3,000,000 injured

Crash Injury for Engineers:

Femur load

HIC

TTI



Real life!

It can't be replicated by dummies and
standardized tests.









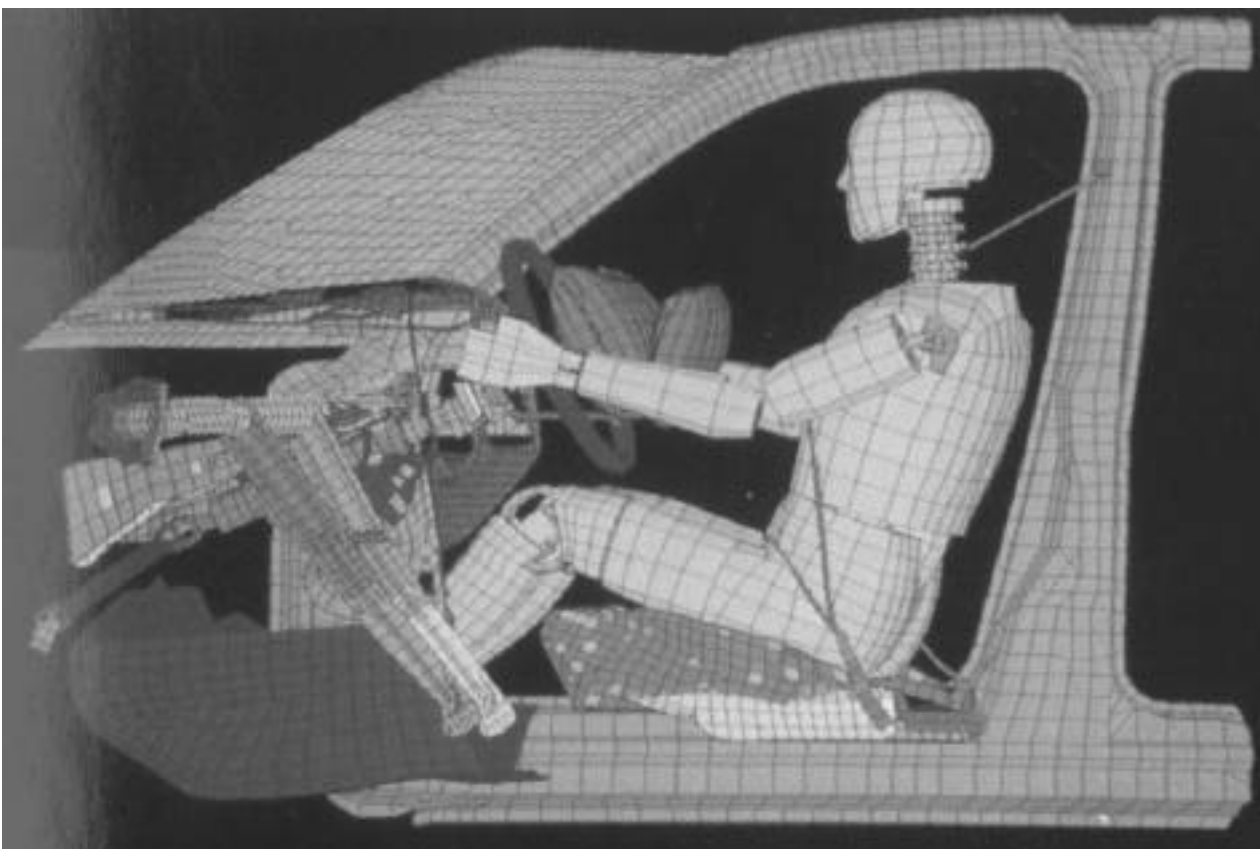
Automotive Safety

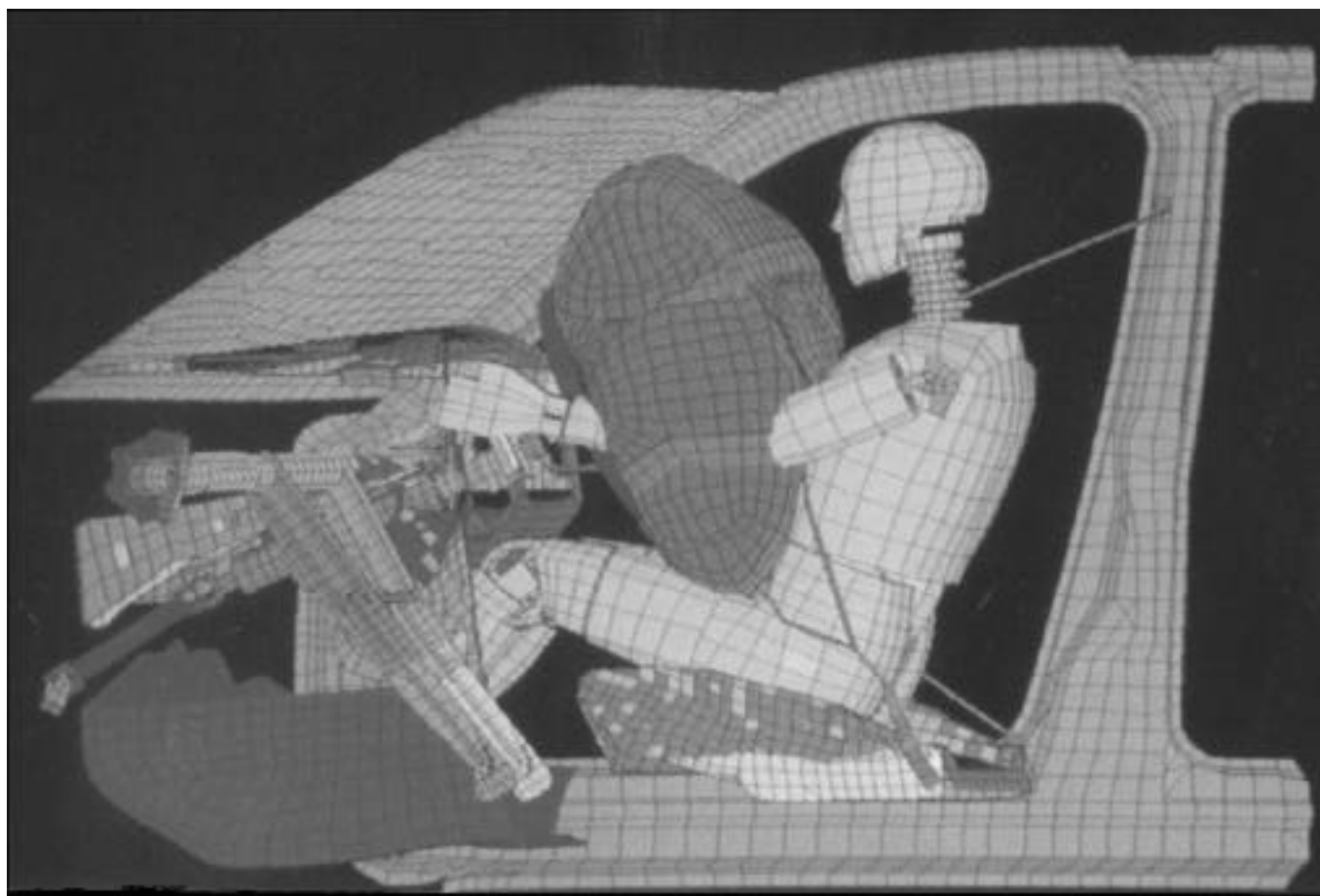
- It's not about numbers, forces, percentages.
- It's about people. Human loss and suffering.

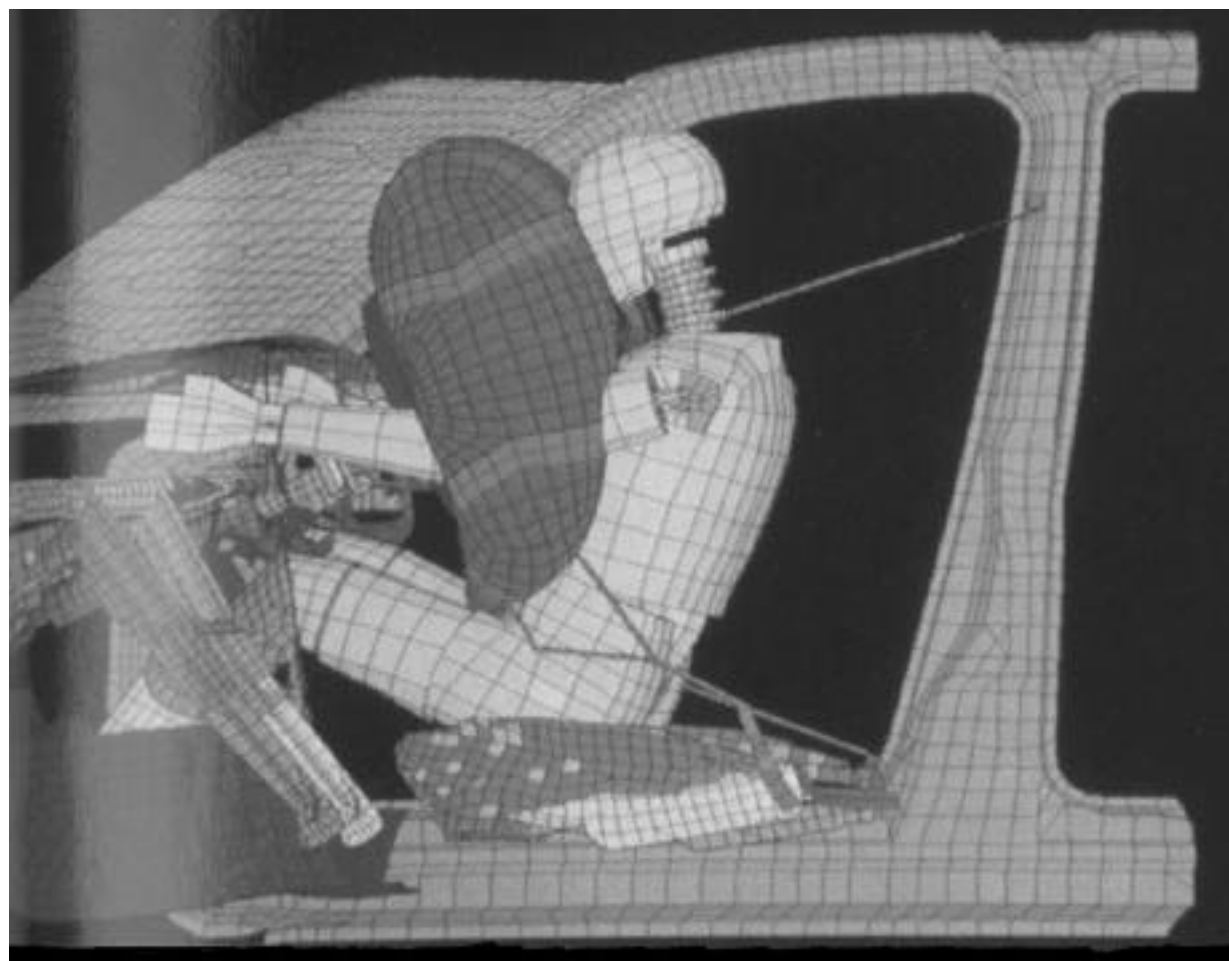


People don't sit still and behave
logically.

Real life crash conditions may not resemble
those in the crash laboratory.







Case 1



- **Case Vehicle: 1995 Ford Taurus**
- **Object Struck: Tree**
- **Impact Type: Offset Frontal (34% VOL)**
- **PDOF: 0**
- **CDC: 12FDEW3**
- **Direct Damage: 46 cm**
- **Max Crush: 81 cm**

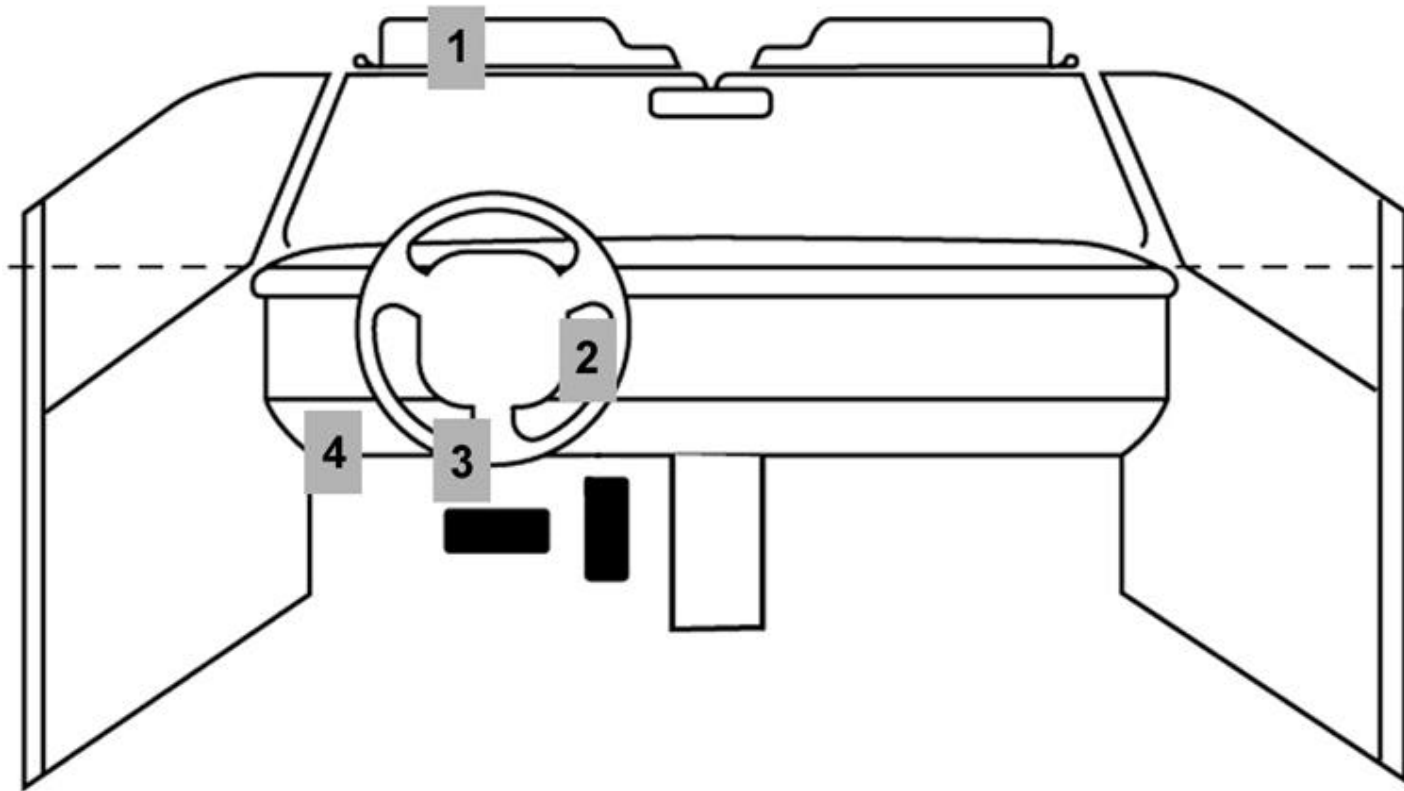






Case Vehicle: 1995 Ford Taurus

Object Struck: Tree



1 = Scuff mark and vanity mirror broken

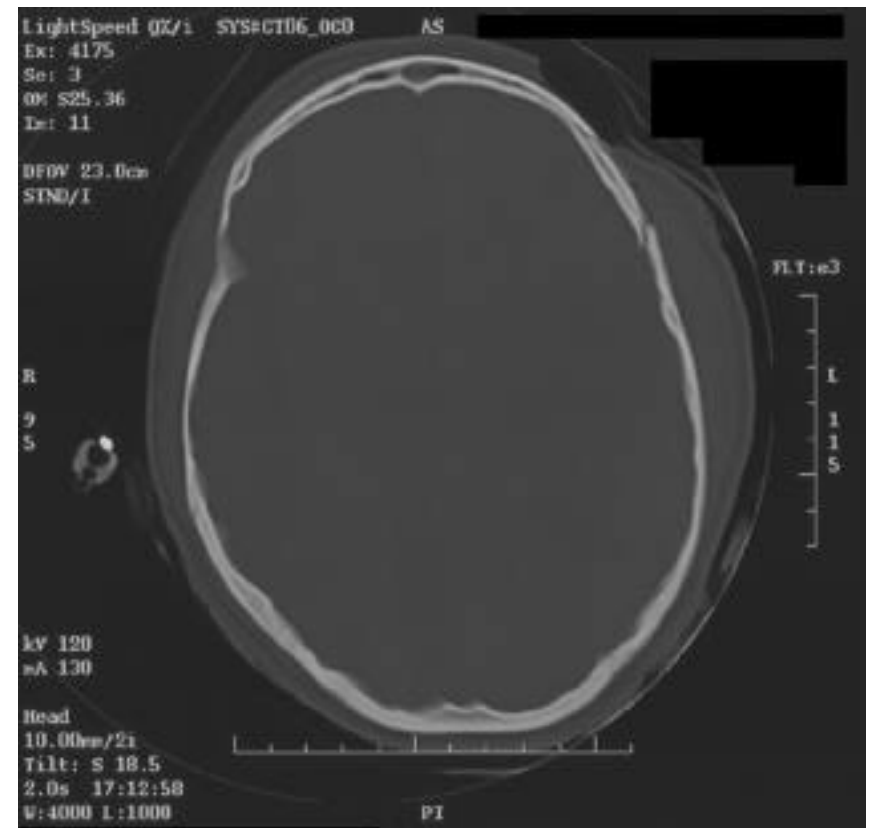
2 = Scuff mark, key top broken and blood deposit

3 = Visible dent

4 = Visible dent

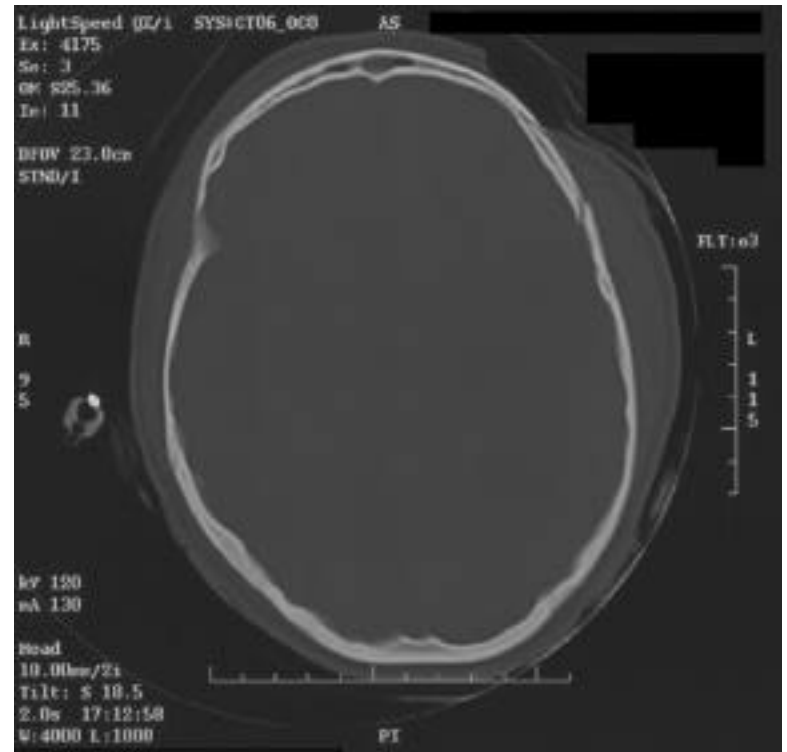


Left forehead laceration
Left frontal bone fracture
Soft tissue swelling















The population is comprised of a diverse collection of individuals.

There are few 50th percentile males.

A

- Female, 165 cm, 77 kg
- Age = 27 years



B

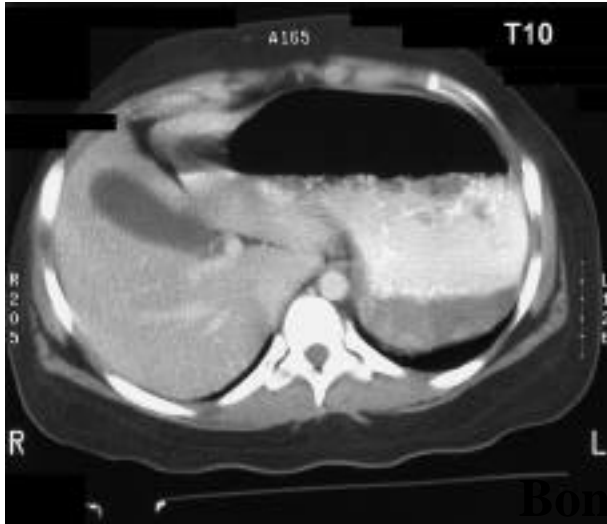
- Female, 165 cm, 78 kg
- Age = 78 years



Body Habitus

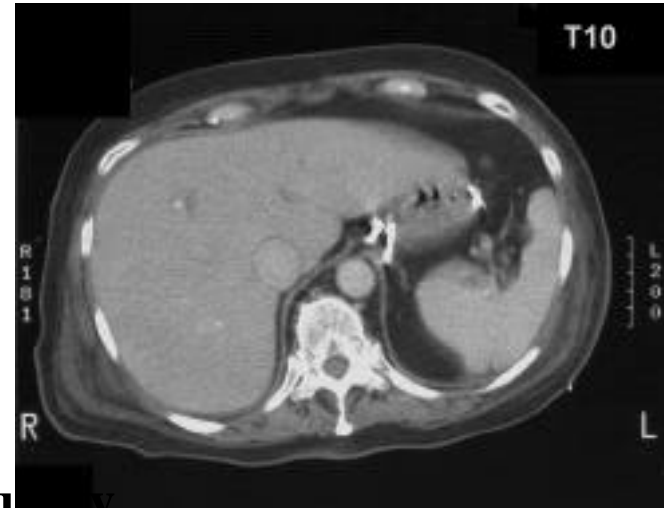
A

- Female, 165 cm, 77 kg
- Age = 27 years



B

- Female, 165 cm, 78 kg
- Age = 78 years



Bone density/quality

C

- **Female, 168 cm, 50 kg**
- **Age = 18 years**



D

- **Female, 165 cm, 49 kg**
- **Age = 72 years**



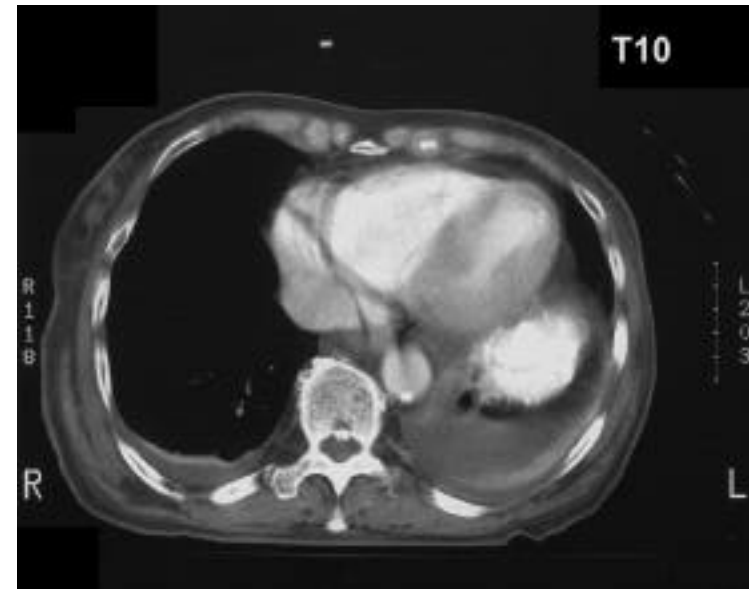
C

- Female, 168 cm, 50 kg
- Age = 18 years



D

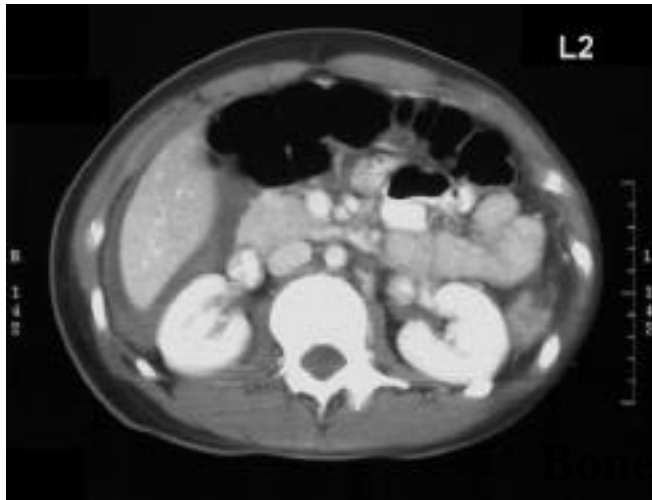
- Female, 165 cm, 49 kg
- Age = 72 years



Bone Density/Quality
Muscle Mass/Quality

C

- Female, 168 cm, 50 kg
- Age = 18 years



D

- Female, 165 cm, 49 kg
- Age = 72 years



Bone Density/Quality
Muscle Mass/Quality

E

- Male, 183 cm, 86 kg
- Age = 38 years



F

- Male, 183 cm, 80 kg
- Age = 79 years



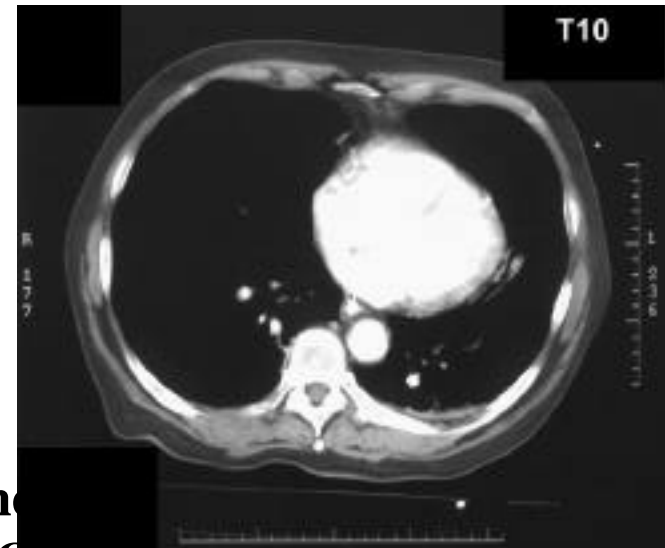
7A

- Male, 183 cm, 86 kg
- Age = 38 years



7B

- Male, 183 cm, 80 kg
- Age = 79 years



Bone Geom
le Mass/Quantity

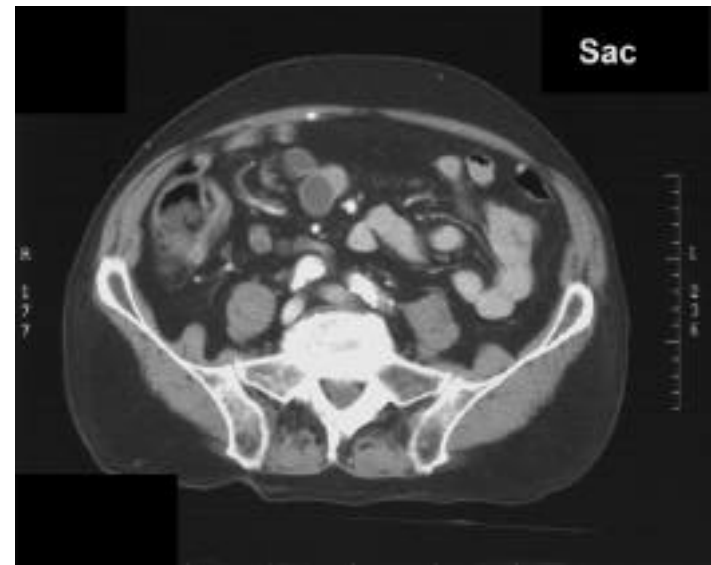
7A

- Male, 183 cm, 86 kg
- Age = 38 years



7B

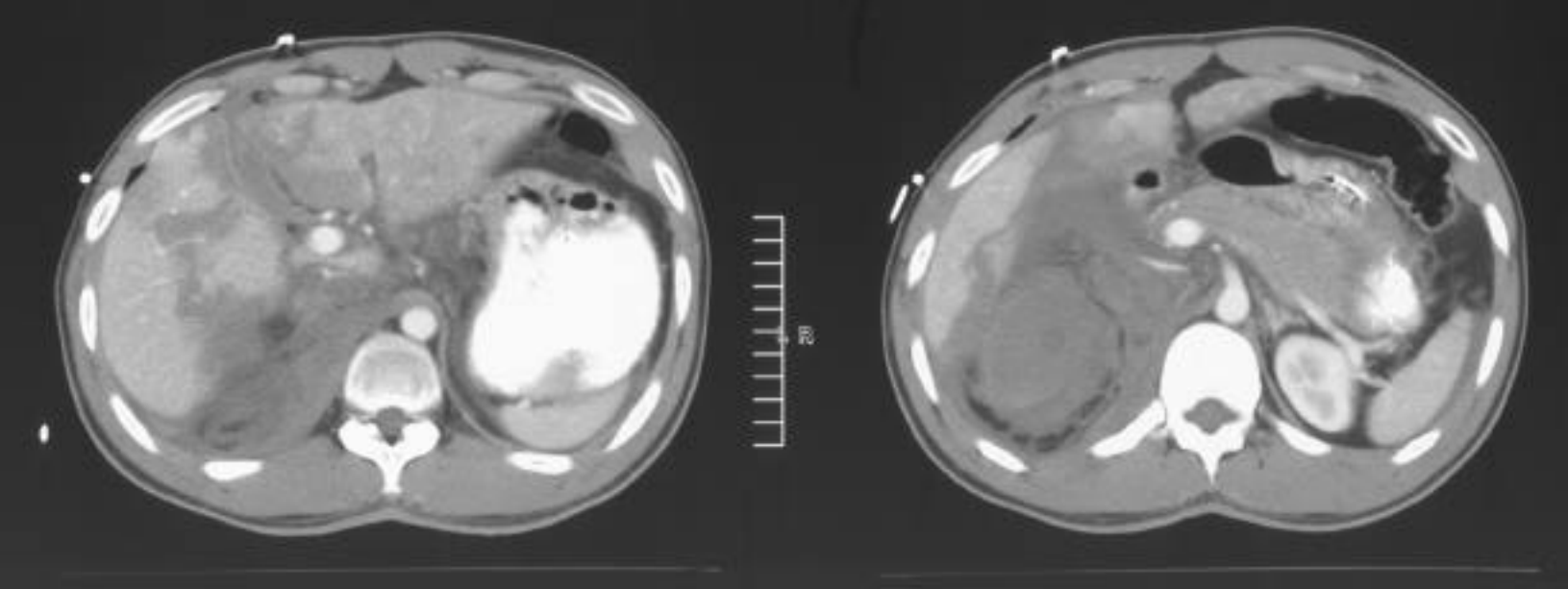
- Male, 183 cm, 80 kg
- Age = 79 years



Bone Density
Muscle Mass/Quality
Fat Mass/Distribution











H

- Male, 38, 178 cm
- Weight = 73 kg



G

- Male, 35, 180 cm
- Weight = 114 kg



Fat Mass/Distribution



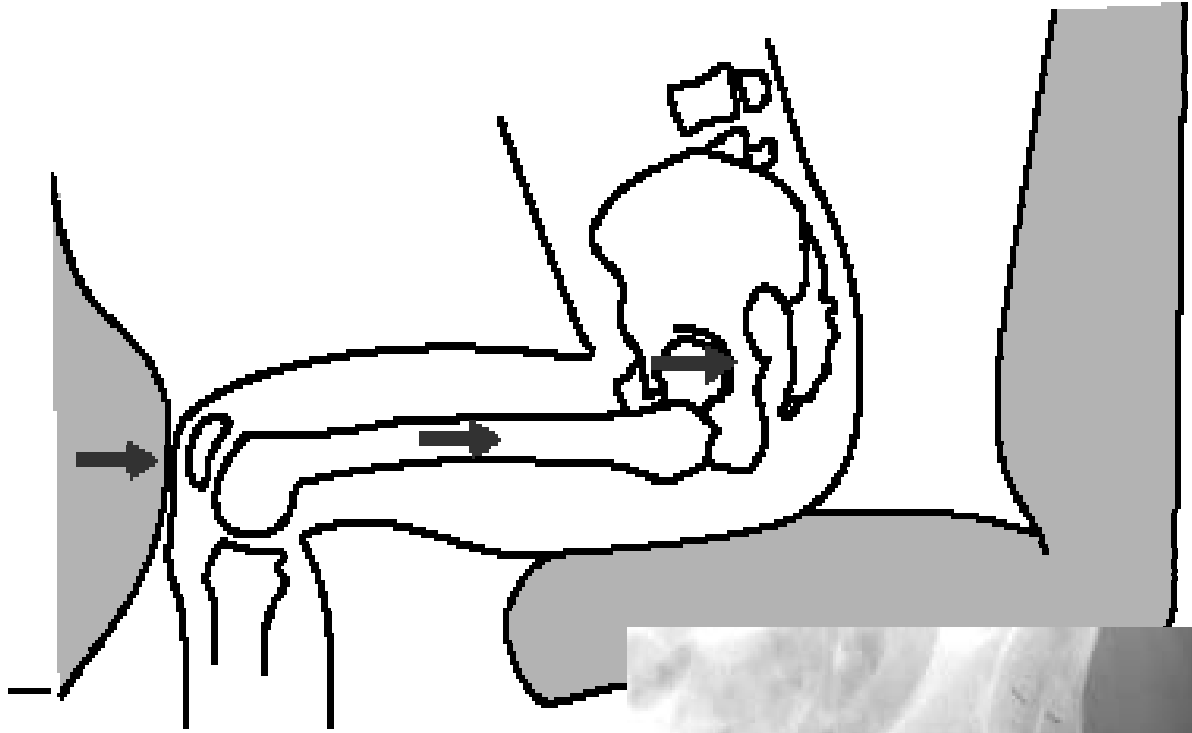
Safety systems effectiveness would be improved if they were tuned for the occupant, like skis for skiers and drugs for patients.

Lesson from medicine: Treat the patient, not the disease.

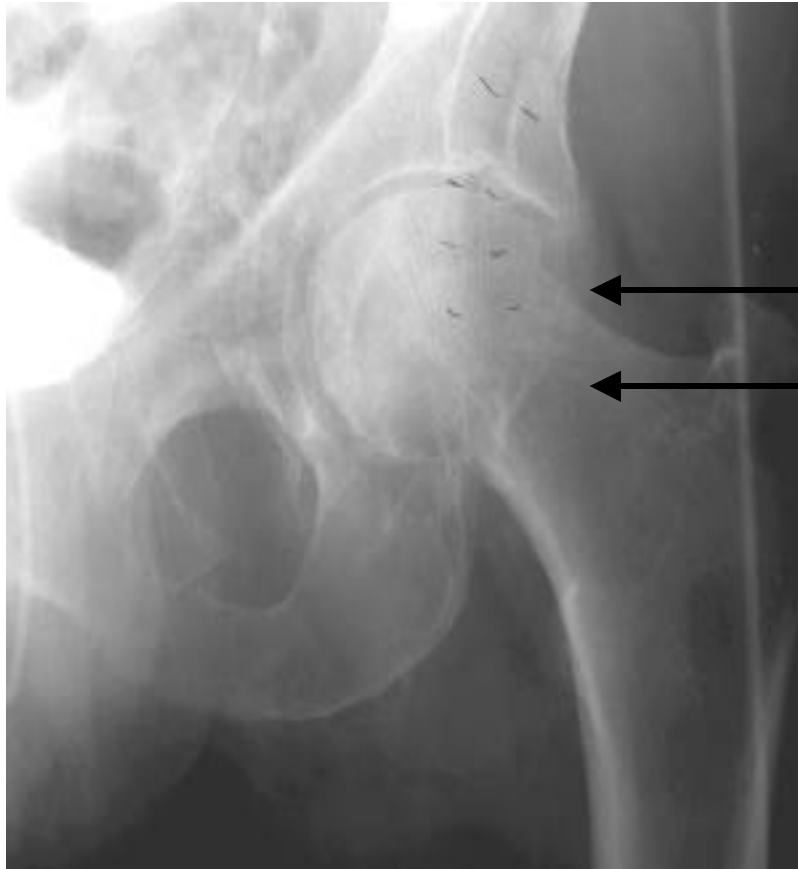
Treatment and prevention must be customized: surgery, chemotherapy, narcotics, antibiotics.

More lessons from medicine

- One can't cure or prevent every disease.
- Problems and solutions need to be prioritized.
- Each intervention has a different risk/benefit ratio.
- Short and long-term outcome of each intervention must be assessed.

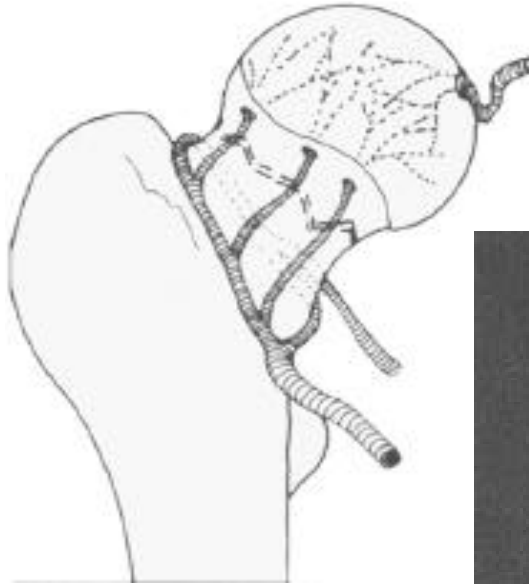






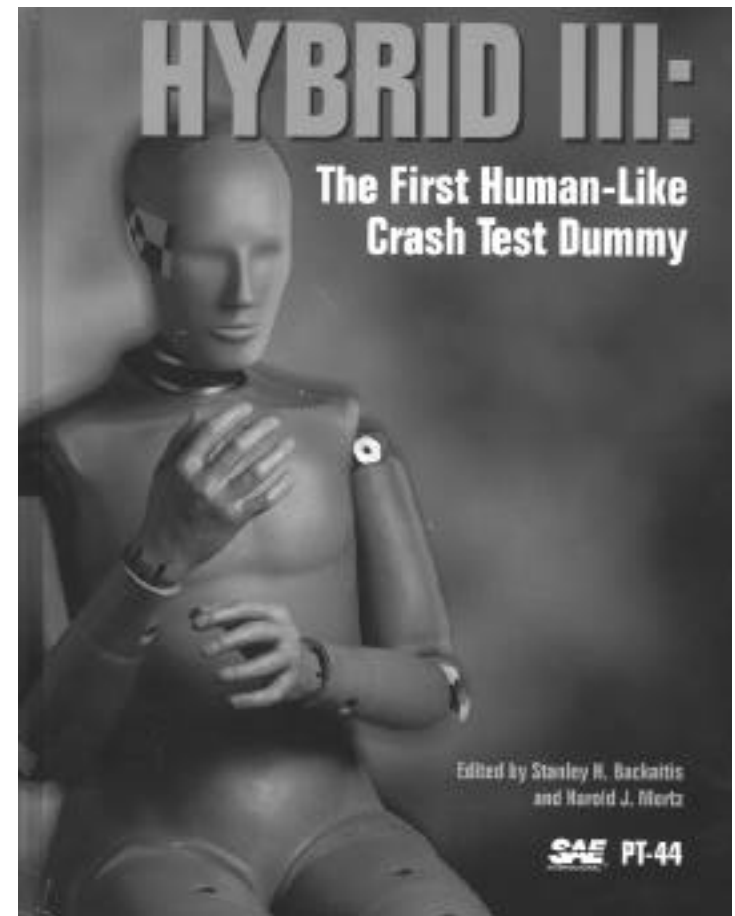






Automotive Safety

- Vehicles are safer than they have ever been.
- Laboratory testing has led to great improvements in safety.



Laboratory findings must be
validated with real life observations.

CIREN

- Thousands of data elements
- Detailed injury analysis
 - Severity
 - Source
 - Mechanism of injury.
- Medical specialists, automotive engineers, bioengineers, crash investigators...



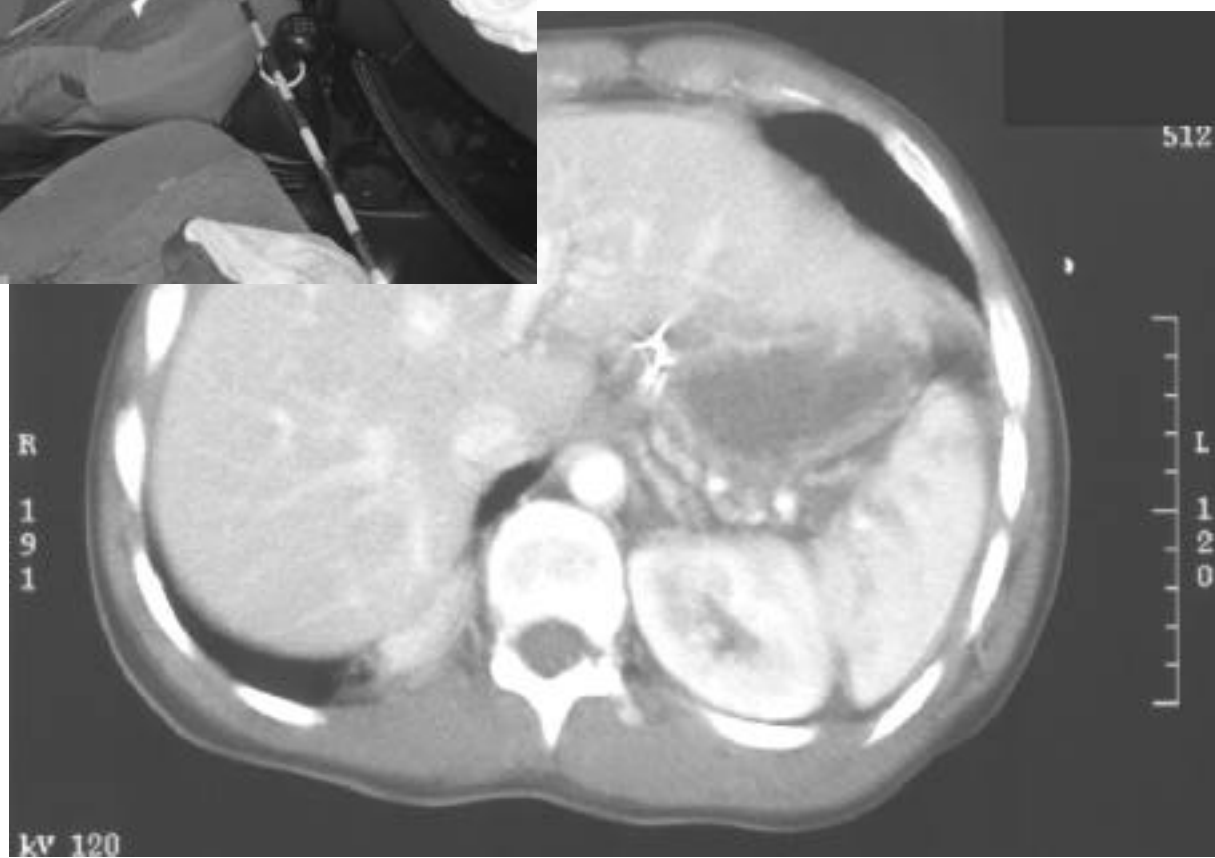




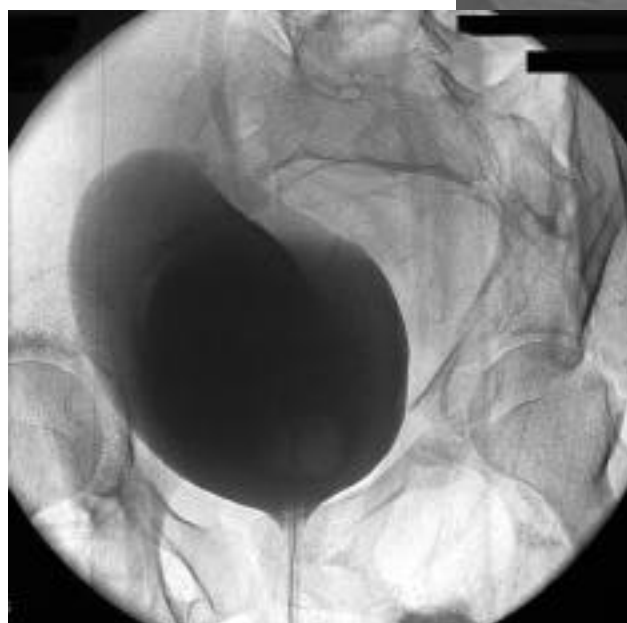














It's difficult to solve a problem without understanding its mechanism.

Typhoid

Polio

Smallpox





There is nothing permanent except change.

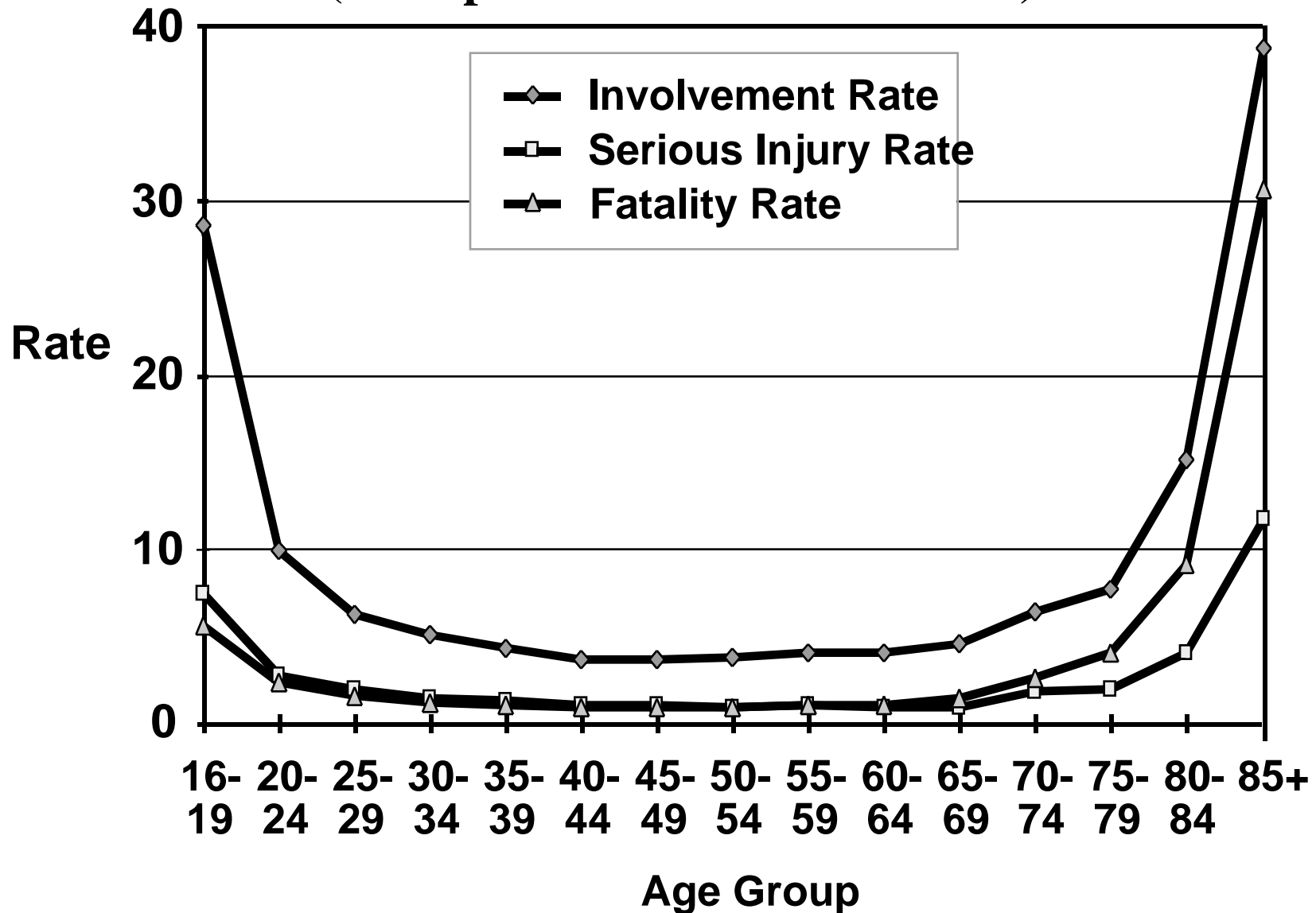
Heraclitus

“The only steady state is death.”

Increase in the Number and Percentage of Older People



Involveent, Injury, and Fatality Rates (rates per vehicle miles of travel)



Vehicle fleet changes as truck sales increase



Vehicle Incompatibility:
Mass, Stiffness, Geometry



In a changing world

- Real-life human data is irreplaceable.
- Reality checks are absolutely essential since all assumptions/approximations are suspect.
- *Golden opportunity at present with the recent introduction of innovative safety systems.*

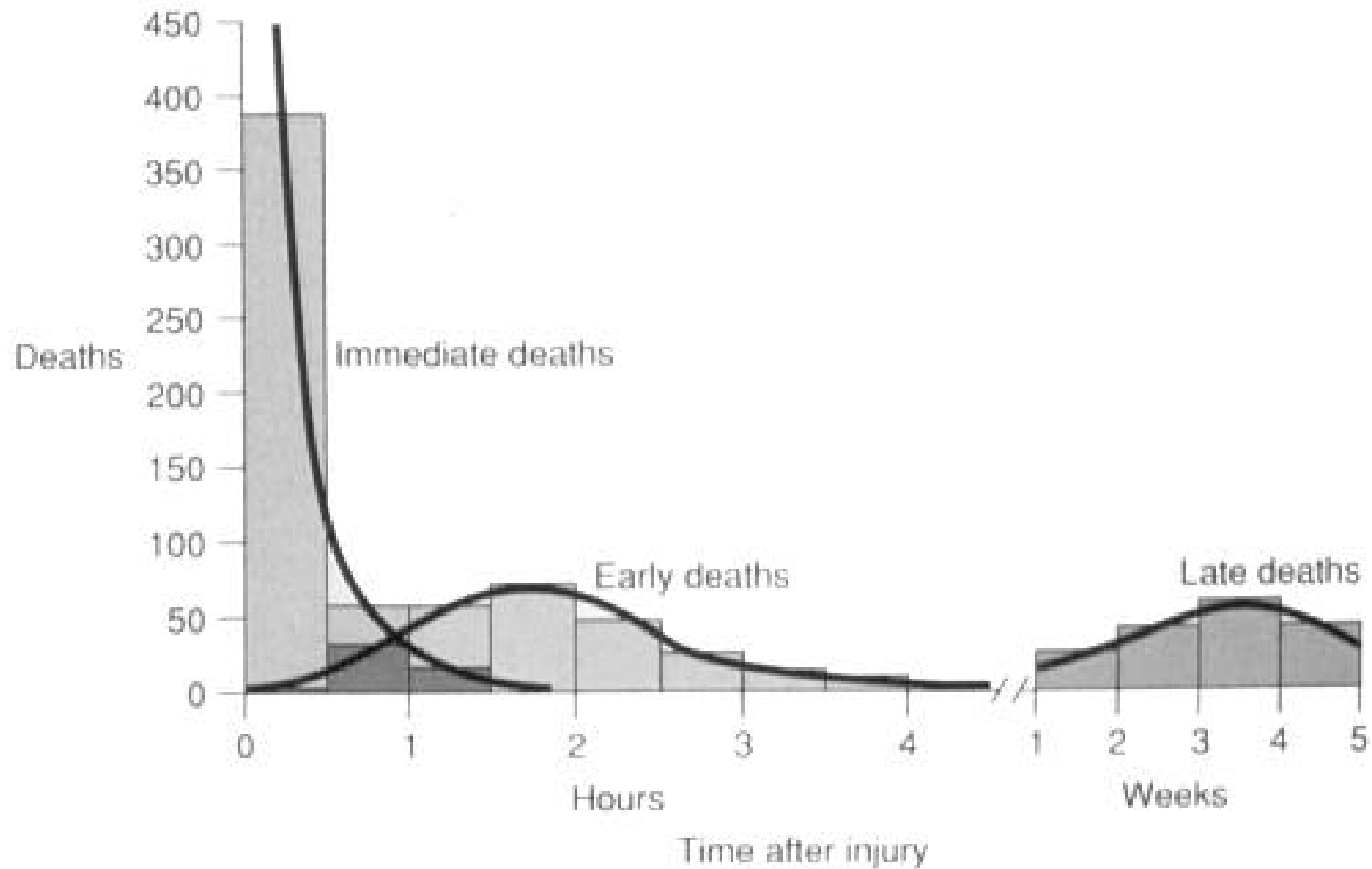
Time is of the essence!

To save injured people.

To make cars safer.



Trauma Deaths



When time is of the essence,
Communication is critical.



OnStar
On Board



Trauma Deaths

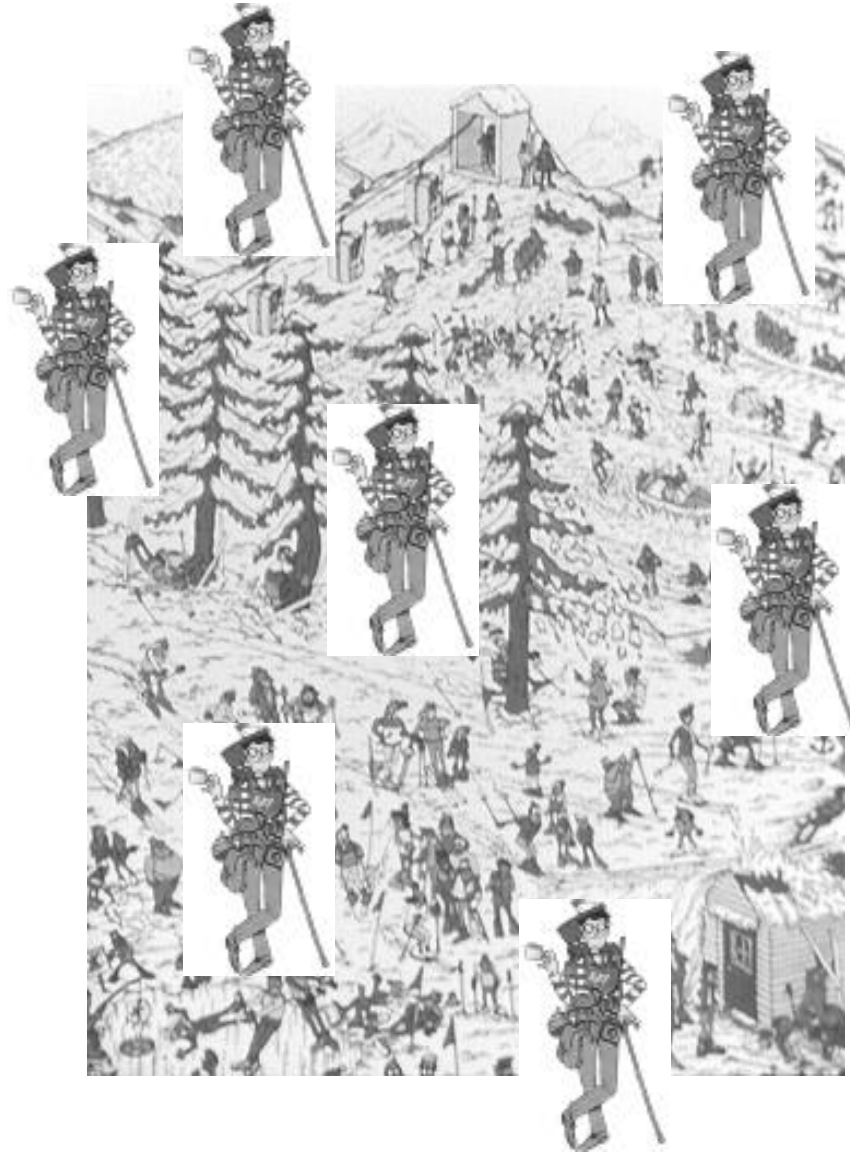
- There are many ways to die:

Airway - face, neck

Breathing - lung, chest wall

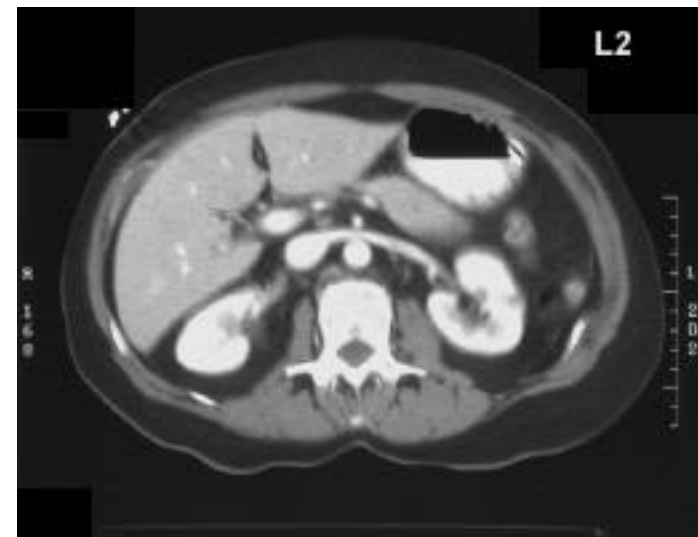
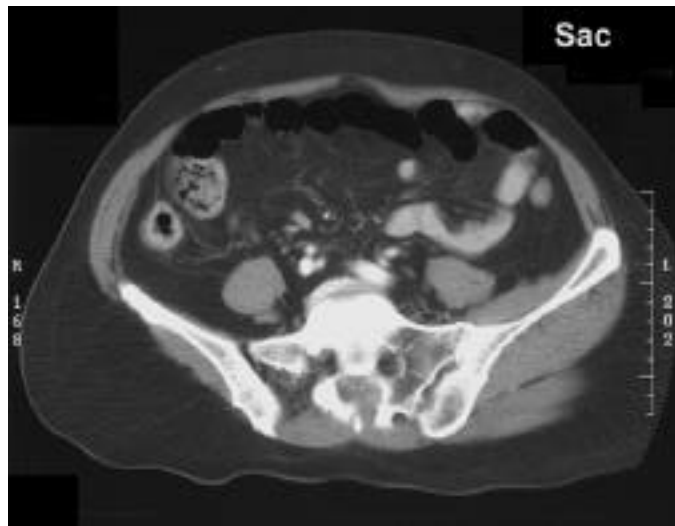
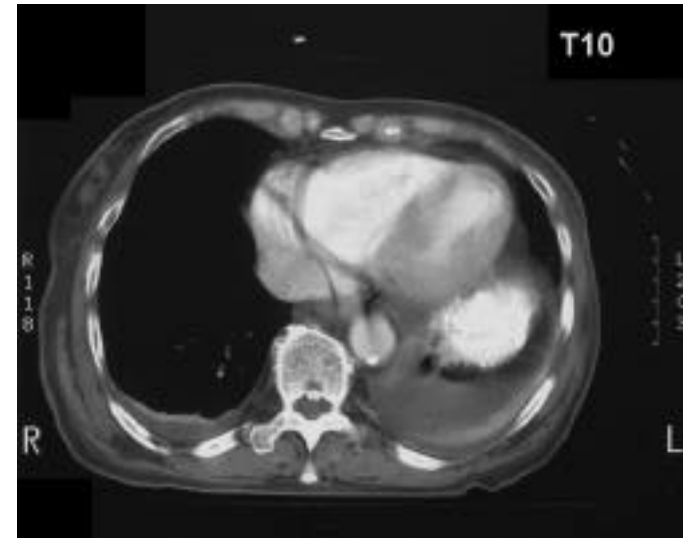
Circulation - heart, blood vessels, organs



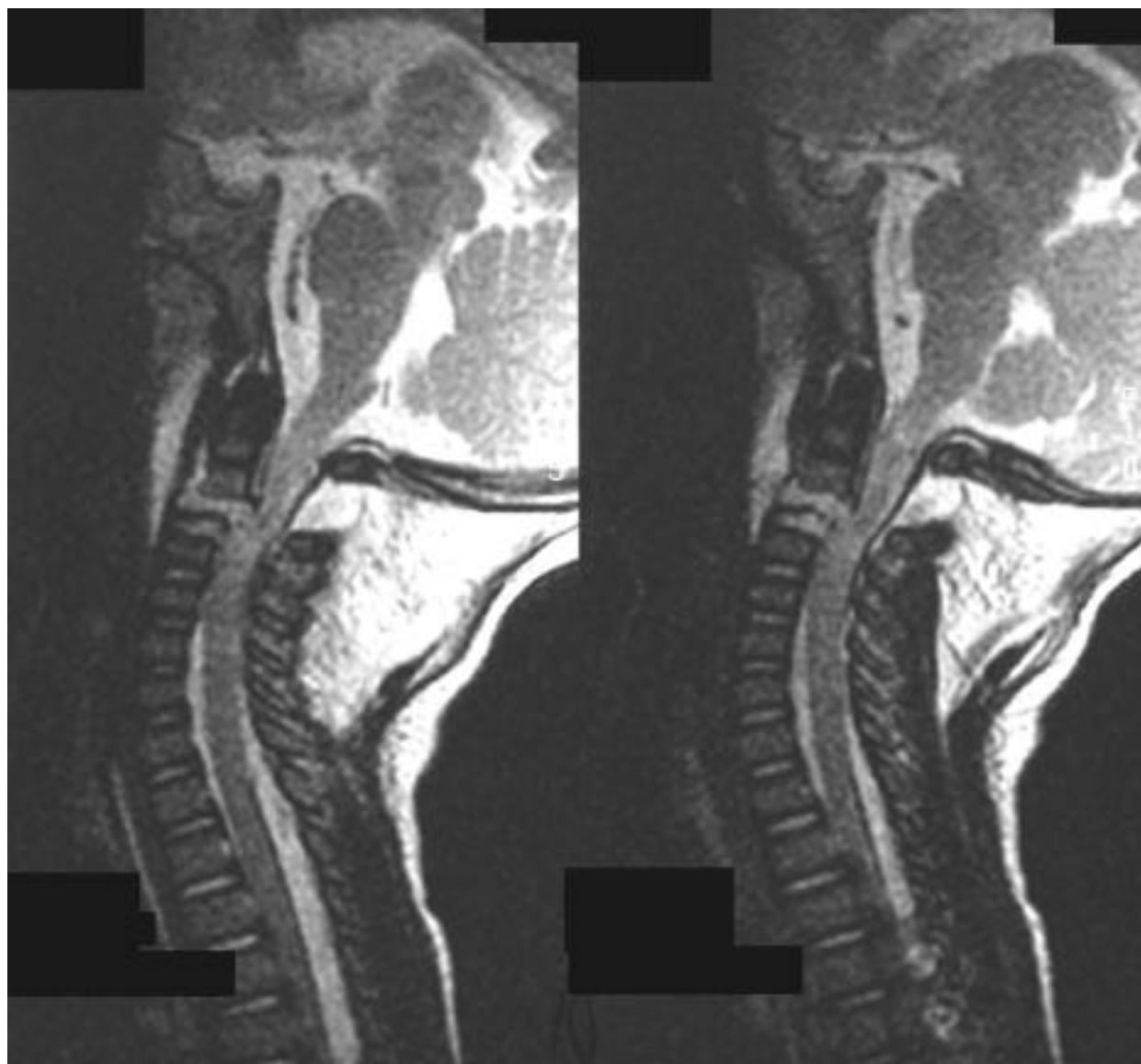


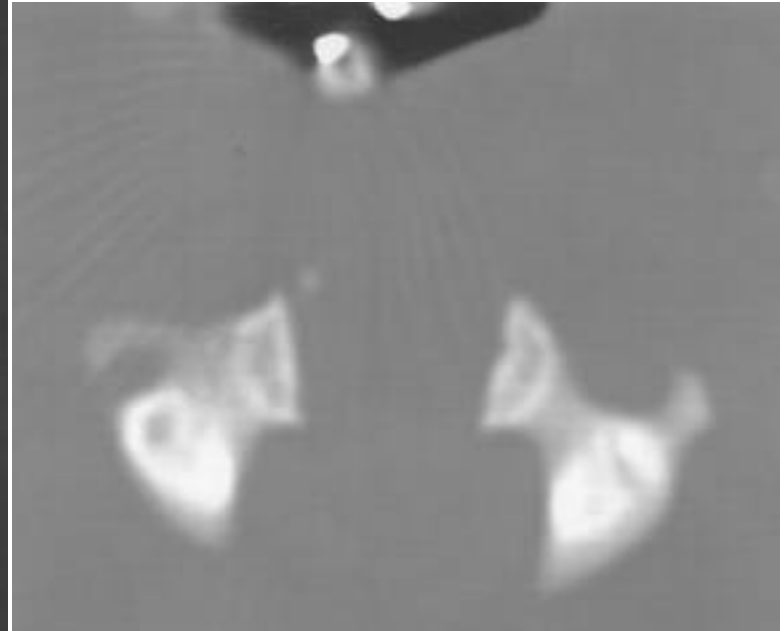
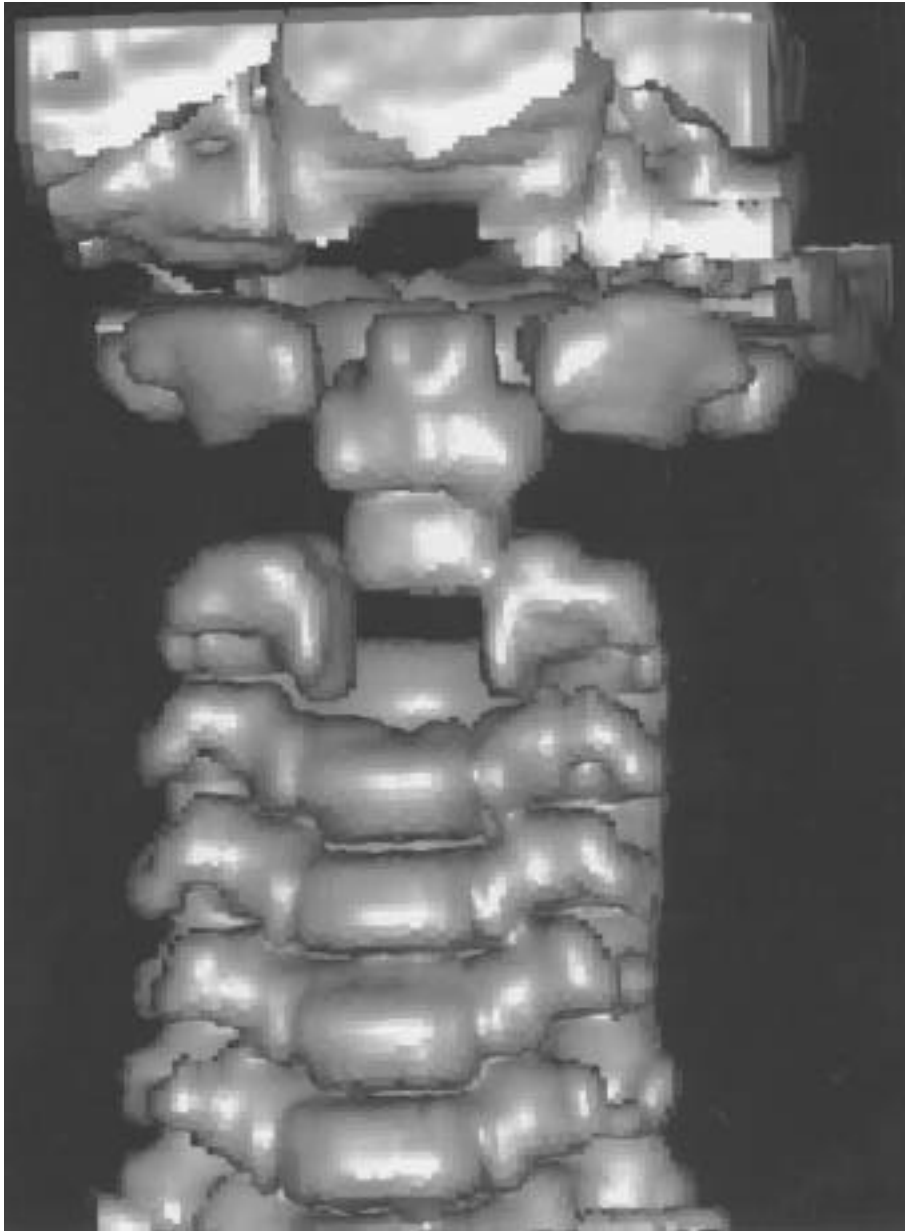














Golden Hour

Notification

Extrication & Transport

Resuscitation

Diagnostic Evaluation

Treatment

Record of the occupant's body's response to the crash.

Anatomic detail, three dimensional.

CIREN subjects are real-life crash dummies.

CIREN

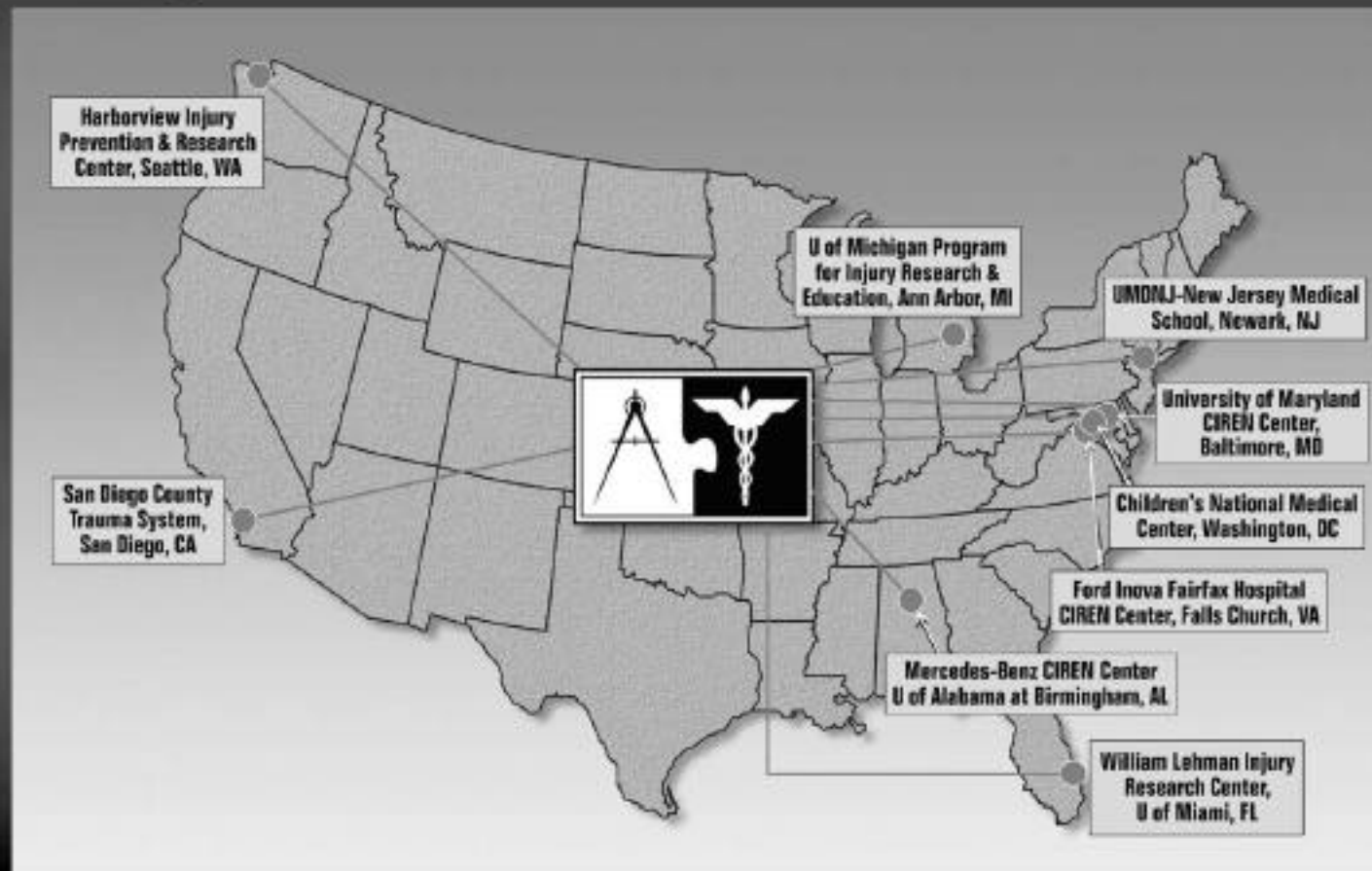
- Engineers, physicians, crash investigators, regulators.....
- Thousands of data elements
- Detailed injury analysis
 - Severity
 - Source
 - Mechanism of injury

CIREN



Not only data....but mutual
understanding and communication...
People working together to save people.

CIREN Network



SELECTED COMMENTS FROM ENGINEERS ATTENDING UMPIRE CASE REVIEWS:

WHY ARE THE CASE REVIEWS VALUABLE TO YOU?

- They help me, and many less experienced safety engineers, think beyond standardized laboratory tests and focus on improving safety in the "real world". They are helpful in better understanding the diversity of occupant and crash parameters affecting safety performance. This includes giving consideration to factors such as injury mechanisms the test dummies are not currently capable of measuring and reduced injury tolerance for elderly occupants. The dialog with the trauma personnel has also improved my understanding of the injury mechanisms in vehicle crashes. I believe, this improved understanding allows me to develop more meaningful and field relevant "evaluation considerations" used in the development of [our company's] restraint systems. The case reviews also provide excellent opportunities to network with others addressing crash safety outside of [our company] and the engineering profession.
- They give me a sense of what happens in real world accidents. It also lets us know how the restraint system performs in these situations. It's almost sort of a customer feedback. The reviews also allow us to look at how the systems perform in situations in which they were not intended to provide protection.
- The opportunity to see how our systems function in the real world keeps things in perspective. We can draw conclusions on what areas need to be focused on for improving performance. We then have support when we speak with product development teams regarding why we suggest a change be implemented.
- It addresses the obvious void between testing or validation with the ATD's (with specified sizes, weights and vehicle positions) and the biomechanics using cadavers (tend to be elderly, female, etc). The driver/passengers within the vehicle interior are not rigid and motionless but in constant fluid motion. The ATD's and biomechanical testing cannot possibly address every possible scenario, however, the CIREN cases fill some of the gaps and can provide direction.
- This type of investigation provides a thorough all perspective on each case. This type of data that could not be obtained by reviewing larger databases such as NASS-CDS. The CIREN cases provide the best illustration of what was the occupant kinematics before and during the crash. Furthermore, the medical input is extremely useful. It is extremely important as we get the medical viewpoint on how injuries are produced. This info is necessary, in particular while trying to identify the benefit of safety countermeasures.
- The case reviews keep me from getting complacent about safety. When dealing with specifications and standardized crash tests, you get used to running an experiment in which many factors are controlled (impact speed, PDOF, seat position, occupant stature, etc.). The case reviews show that nothing is fixed or set in real-life crashes, and they force automotive engineers to go look at what the variables were and how they influenced the crash outcome. In a standardized crash test, there are certain things to look for; after my first case review, I realized that there are other things I should also consider; and each subsequent CIREN case has only added to this understanding.

- The case reviews at the CIREN meetings give me an opportunity to view crash as a real life event, rather than a test with dummies. There are many things I have learned from these meetings that one cannot learn in a test lab. CIREN case reviews help us, as engineers, see what are the major causes of injury in real life crash events and work to improve these factors. These reviews also help us to understand the performance of our components in real life.
- Cases are valuable because they shed light on injury causation potentially out of the sphere of conventional auto industry due care and validation testing. This provides potential opportunities of improvement to the vehicle.
- Case reviews are very valuable to me because a lot of detailed information was delivered during the review and discussions such as the impact situation, injury types, interaction between the occupants and the interior of the vehicle. Especially with the aid of slide presentation, it is much easier to understand the cases.
- Case reviews are valuable in that the open discussions, the various crash vehicles and conditions as well as the medical input will undoubtedly lead to safer designs. Typically, engineers look at data from test dummies and simulations. To be able to discuss and analyze what are real world situations with colleagues from competitor companies has heretofore not been an option. I look forward to continued participation.
- Learning experience from medical aspect; and learning and experience about how design/engineering affects safety; learning about the injury types that occur that we do not design for; networking with people in industry
- Helps me understand the direct causation between the injury and the crash
- It allows me to interact with and learn from the engineers who develop today's automotive safety systems. I am exposed to the shortcomings and successes of these systems. I am also educated monthly on a subject which is the number one killer in persons aged 6-33 years. I am also exposed to the problems experienced by prehospital personnel and the long term effects felt by the victims of these motor vehicle crashes.

WHAT HAVE YOU LEARNED FROM THE CASE REVIEWS?

- Overall, the restraint systems in the newer vehicles are of benefit to people. People are surviving accidents that they would not have survived before. This, however, may also be responsible for certain types of injuries becoming more prevalent, such as acetabular fractures and tibia/foot fractures. It is unclear if these increases are due to an actual increase in the number of injuries or just that more of these injuries are being treated, since more people with them are surviving.
- I have also learned a lot about what happens in an emergency setting, from extrication to the emergency room. One thing that may not be encompassed in vehicle design is removing people from the vehicle after an accident. It is also eye-opening that many of the accidents involving serious injury involve falling asleep/losing consciousness, drugs and/or alcohol and that they aren't all at night.
- In addition to the above, I have learned a lot about hip/acetabular injury mechanisms.
- The case reviews have allowed me to realize the significance of lower leg and pelvic injuries. It is also interesting to be able to draw general conclusions about how the occupant's age may affect the sustained injuries.
- The obvious items that stand out are the vast number of hip injuries from frontal impacts as well as internal organ injuries from side impacts. Addressing these issues was something I had not considered before the CIREN case reviews. The federal specs address femur loads and thoracic trauma. It is similar to addressing the primary issues, only to find now the secondary issues that need to be addressed. The CIREN cases give us a heads up on the secondary and tertiary issues.
- The case reviews help me understand how countermeasures are performing in the field. It helps me assess the potential benefits of other safety devices that we may be working on. For example, the review of airbag performance in field, in particular in offset or oblique impacts, would not be attainable from looking at CDS databases or from carrying out computer simulations or sled tests.
- No two accidents are alike, and standardized tests (even though they are a good and necessary starting point to evaluate vehicle safety) only scratch the surface of what happens in real life.
- I have learned about the complexities of real life kinematics. I have also learned about the gaps in vehicle testing, and that regulatory improvements are needed to better align vehicle testing with real world events. Overall these reviews help us to become better engineers. Each of these cases puts a face in front of us. We see the results of a crash on a human body. This makes a very emotional connection. I now recognize even more how the dummy is only a tool, but the Moms, Dads and Children out there are the real people we are working for.
- Although I've attended few meetings, I've seen case reviews that have elicited issues we've suspected as potential injury contributors and are now formulating test methods to objectively review these suspected systems performance.

- Mainly have seen how easy it is to get a laceration from seemingly little disruption in surfaces.
- From these case reviews, it help me to understand better about how the vehicle design will effect the safety performance and what should be considered to better protect the occupants.
- In several cases, the root cause of an injury in fact quite simple thereby implying the solution could be simple as well. Another testament to the importance of the program. Without the discussion and analysis with the group, the potential solutions could be overlooked.
- I am impressed with how the reviews have been conducted and the quality of input from doctors, surgeons, OEM's, automotive suppliers, etc.

DO YOU HAVE ANY CONCRETE EXAMPLES OF INFORMATION YOU WERE ABLE TO USE IN A PRACTICAL MANNER AT WORK?

- By being able to cite the high incidence of leg injuries, there is evidence to go to the product design teams and work on designing a better restraint system to help prevent these types of injuries.
- Information from the case reviews serves as another data point to assist in decision making when trying to design and optimize, as much as possible, a restraint system.
- The performance of knee bolster. The CIREN data seem to indicate that in offset crashes, knee and femur injuries seem to have decreased but pelvis injuries increase. This may make us rethink the design of knee countermeasures. Airbag performance in offset and oblique impacts also provide some insightful information
- I can't give a specific example, but I'd claim that several belt restraint issues are apparent in the cases reviewed.
- I have relayed some of these observations to the design groups to reduce sharp edges in their design. And try to engineer designs that discourage people from being distracted by having too many buttons or put controls within easy reach so that they are not taken away from the road.'
- Since I am a safety engineer specialized on the dummy analysis of frontal and side impacts. These reviews really helped me to think about the restraint system design and injury mechanisms.
- Nothing accomplished, but it has given me ideas to investigate: to improve safety by design e.g. Acetabular fracture relationship to knee separation. I am to develop technology that will drive knees apart better in frontal impact.
- I believe the biggest impact came from the UMPIRE / CIREN Team presentation last summer. Most of our engineers never deal with vehicle safety / crash testing themselves, they only see the specifications. They walked away more aware that "this is what an accident really looks like" and I think they were able to associate pictures and outcomes with the numbers and formulas.